BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Implementation of Sections 3(n) and 332 of the Communications Act	)	**GEN Docket No. 93-252**
	)	
	)	
Regulatory Treatment of Mobile Services	)	

COMMENTS OF
THE SOUTHERN COMPANY

The Southern Company ("Southern"), by its attorneys and pursuant to Section 1.415 of the Federal Communication Commission's rules, submits these Comments in response to the Further Notice of Proposed Rule Making ("Further Notice") released May 20, 1994 in the above-captioned proceeding.[1/]

I. SUMMARY

1. Southern supports many of the Further Notice's pragmatic proposals. In considering these issues, however, the Commission must avoid impractical levelling of the regulatory plane and levelling made at the expense of fuller competition in different Commercial Mobile Radio Service

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1/ Implementation of Sections 3(n) and 332 of the Communications Act, Regulatory Treatment of Mobile Services, GEN Docket 93-252, Further Notice of Proposed Rule Making, FCC 94-100 (released May 20, 1994).

("CMRS") markets. In particular, some of the Further Notice's suggestions seem to play down the marked, real-world differences between cellular and wide-area Specialized Mobile Radio ("SMR") services for the sake of creating the appearance of regulatory parity. Southern urges the Commission to promote competition through qualitative parity, instead of superficial parity, by adopting carefully tailored regulations that recognize these differences.

2. For example, Southern supports eliminating the SMR loading requirements only as long as the Commission retains an effective channel recovery program. Southern supports SMRs' continued ability to define their own service territories (or "footprints") and to modify stations within their footprints on a first-come, first-served basis. Southern opposes changing the SMR co-channel protection criteria, the SMR standard for Special Temporary Authority ("STA"), SMR application fees, and any interoperability requirement. These positions offer wide-area SMRs the degree of regulatory flexibility they require to develop competitive CMRS systems, but would not diminish qualitative parity with cellular carriers.

3. Southern also believes that, to ensure effective CMRS competition, any spectrum cap must be targeted at

individual CMRS services, rather than at gross spectrum amalgamations. Service-specific caps will foster competition within each relevant market because, for the foreseeable future, different services will employ different technologies and will serve separate markets. A gross cap, on the other hand, could impair competition by allowing firms to achieve bottleneck control over SMR frequencies in metropolitan areas while staying under the overall cap. To avoid this possibility, the Commission should limit 800 MHz licensees to using no more than 140 frequencies for the provision of wide-area SMR service in any particular Metropolitan Statistical Area. This is half the 800 MHz SMR category spectrum, and it is sufficient to support the development of two competitive wide-area SMRs in each area.

II. STATEMENT OF INTEREST

4. Southern is the licensee of an 800 MHz wide-area SMR system which, upon completion, will provide state-of-the-art digital service throughout Alabama, Georgia, the panhandle of Florida, and southeastern Mississippi.[2/]

[2/] Southern is an electric utility holding company which wholly owns the common stock of five electric utility operating companies -- Alabama Power Company, Georgia Power Company, Gulf Power Company, Mississippi Power Company, Savannah Electric and Power Company -- and a system service company -- Southern Company Services, Inc. -- which together operate an integrated electric utility system which serves

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Southern anticipates using its stations primarily to provide mobile radio service to its affiliated utility companies. It also anticipates providing interconnected mobile radio service to the public on a for-profit basis; i.e., as a CMRS provider. As such, Southern will be directly affected by the outcome of this proceeding.

III. DISCUSSION

5. As the Further Notice recognizes, Congress has instructed the Commission to modify its rules only "as may be necessary and practical to assure. . .comparable" regulation among "substantially similar" services.[3/] The Further Notice notes that, by requiring only practical and comparable regulation, Congress has given the Commission substantial flexibility in implementing its mandate and that

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[2/](...continued)
over 11 million consumers in a contiguous area of 122,000 square miles, including most of the State of Alabama, almost all of the State of Georgia, the panhandle of Florida, and 23 counties in southeastern Mississippi. Southern is in the process of improving its mobile radio communications and is implementing a wide-area, digitally-enhanced 800 MHz system. Southern will sell the excess capacity of its system to state and local governments, utilities, industrial and commercial users, and other customers who can use the dispatch, two-way voice, and data transmission capabilities of Southern's wide-area SMR system. The Southern wide-area SMR system will provide service in rural and urban areas corresponding with its utility system operations.

[3/] Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103-66, Title VI, § 6002(d)(3), 107 Stat. 312, 397 (1993) ("Budget Act") (emphasis added).

ultimately market forces rather than regulations should guide CMRS choices. Further Notice at 13.

6. Certain proposals, however, seem to ignore the impact existing regulations already have had on the development of SMR and cellular services. Although wide-area SMR and cellular services superficially might appear similar, the underlying structure of the two systems are markedly different. The Commission must recognize these longstanding differences and therefore must carefully craft service-specific regulations in order to ensure each industry reaches its full market potential. Regulations which, for the sake of the appearance of parity, hinder the development of a vibrant wide-area SMR market ultimately will frustrate Congress's goal -- to maximize competition in CMRS markets.[4/]

A. Technical and Operational Rules

1. The Commission Must Maintain Effective Rules to Avoid Warehousing of SMR Spectrum

7. Two facets of SMR operation complicate the Commission's ability to create comparable regulations for wide-area SMRs and cellular carriers: disparate spectrum resources and the ability to employ those resources. The

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4/ See id., 107 Stat. at 393.

amount of spectrum available to the SMR market is minute in comparison with the cellular allocation. SMRs also have far less flexibility in using that spectrum since they compete with all other SMRs in licensing frequencies on a site-by-site basis.

8. Given the limited amount of SMR spectrum, it is critical that all channels be used to their fullest capacity. The Further Notice, however, proposes to (1) liberalize the slow growth rules for 800 MHz wide-area SMRs, (2) eliminate or modify the 40-mile rule, and (3) eliminate the automatic cancellation component of the SMR loading rules. Further Notice at 33-35. Despite the Commission's best intentions, these proposals could foster spectrum warehousing and, effectively, exhaust the 800 MHz SMR pool forever.

9. To avoid this possibility, the Commission must maintain effective safeguards so that unused SMR spectrum is available to those entities that require additional communications capacity on constructed systems. To this end, Southern urges the Commission to continue to review slow growth applications to ensure legitimacy and to ensure that valuable 800 MHz spectrum will be used in a timely

fashion. If 800 MHz SMRs are to reach their full potential, licensed 800 MHz spectrum cannot lie fallow.

10. Southern does not oppose eliminating loading obligations for Part 90 CMRS licensees, and it generally supports the Commission's proposed construction rules, especially the redefining of a licensee's service area based on actual construction and the reclaiming of unconstructed authorizations by the Commission. However, with the proposed liberalization of loading and slow growth rules, the Commission must sternly enforce its construction requirements.

11. Specifically, Southern is concerned that current SMR construction requirements are inadequate in light of the increasing demand for 800 MHz spectrum.[5/] In their place, Southern proposes that the Commission implement construction rules similar to those which initially governed Part 22 cellular providers. By adopting Part 22 cellular construction rules, SMRs will be required to provide evidence of construction, such as site maps and frequency

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5/ The Commission has had ongoing difficulty in enforcing the SMR construction rules driven in large part by the "SMR on wheels" problem. See, e.g., Order, 8 FCC Rcd. 7309 (1993) ("SMR on wheels" does not constitute permanent construction).

utilization plans, that the Commission can review to ensure compliance with construction obligations.[6/] Legitimate construction requirements are necessary and practical to ensure that (1) constructed and operational SMR providers have access to additional frequencies for system expansion, and (2) unused frequencies are promptly returned to the Commission for re-licensing upon expiration of a licensee's implementation period.[7/]

2. SMR Providers Need to Self-Define Their Service Territories

12. Southern opposes any Commission-defined service area for wide-area SMRs. If wide-area SMRs were being developed in "clear" spectrum, as cellular systems have been and PCS systems will be, Commission-defined service territories might be appropriate. However, due to the lack

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6/ Recently, the Commission proposed relaxing the showing cellular carriers will have to make to demonstrate construction; namely, eliminating the requirement for a frequency utilization plan and for system maps which depict site deployment within Cellular Geographic Service Areas ("CGSAs"). Revision of Part 22 of the Commission's Rules Governing the Public Mobile Services, CC Docket No. 92-115 Further Notice of Proposed Rule Making, FCC 94-102 (released May 20, 1994). These requirements should be implemented for wide-area SMRs since scarce spectrum is licensed for specific sites.

7/ Southern supports the Commission's proposal to limit initial frequency assignments by requiring a licensee to construct and provide service on existing channels prior to receiving additional frequencies in the area. Further Notice at 34.

of 800 MHz SMR spectrum available for licensing, wide-area SMRs would find it impossible to develop systems covering Commission-imposed territories. Wide-area SMRs must be allowed to continue to establish self-defined service areas and to select appropriate channels based on existing spectrum conditions.[8/]

3. Southern Supports Only Those Further Changes to Part 90 Technical and Operational Rules that Are Necessary and Practical to Allow SMRs to Develop Vibrant Systems

13. Southern urges the Commission to maintain existing co-channel interference protection criteria for all 800 MHz SMR licensees. Further Notice at 20-22. Millions of dollars already have been invested developing wide-area SMR systems to conform with the current protection rules (which the Commission revised only recently). This work would be jeopardized if the Commission now were to require licensees to adhere to different co-channel interference protection criteria.

14. Southern objects to any Commission action that would decrease the antenna height and power limitations for

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8/ As touched on above, Southern encourages the Commission to allow wide-area 800 MHz licensees to have a fixed period of time to build out their self-defined systems based on the existing extended implementation rules for SMR systems.

800 MHz SMR licensees in an impractical and unnecessary effort to conform to cellular rules.[9/] Southern also contests any immediate imposition of interoperability requirements because of the burden it would place on emerging SMR systems, such as its own. See Further Notice at 23-28.

15. Southern strongly supports the Commission's proposals to eliminate all user eligibility limitations applicable to CMRS providers under Part 90 and to eliminate existing rules that restrict communications of Part 90 CMRS licensees. Southern also encourages the Commission to allow wide-area systems to employ a single call sign on a system-wide basis and to develop rules that will make it easier for wide-area 800 MHz SMRs to comply with these identification rules in the digital future. Southern supports the proposal to eliminate Part 90 general licensee obligations as set forth in the Refarming Notice.[10/] Further Notice at 35-39.

[9/] Southern supports the Commission's alternative to limit station power at the licensee service border while allowing the licensee to have flexibility over station power within its service area, consistent with protecting co-channel licensees.

[10/] The Refarming Notice proposes to eliminate ministerial obligations such as those governing operator requirements, posting of station licenses, and responses to official communications. Notice of Proposed Rule Making, PR Docket No. 92-235, 7 FCC Rcd. 8105 (1992). As the

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These rule changes are appropriate if Part 90 CMRS providers are going to be able to develop vibrant CMRS systems.

16. Southern also encourages the Commission not to limit the types of transmissions that may be used on 800 MHz CMRS systems so long as licensees comply with technical requirements. Southern urges the Commission to maintain existing emission mask rules for CMRS providers because specific emission limitations are dependent on service-specific factors such as bandwidth and channel spacing. See Further Notice at 22-27.

B. Licensing Rules and Procedures

17. The Further Notice suggests that all CMRS applicants in Part 90 services should pay filing fees "equivalent to the fees already paid by Part 22 common carrier applicants"; i.e., $230 per application. Further Notice at 51. Given wide-area SMRs' and cellular licensees' disparate histories, this proposal in practice will foist substantially greater fees on wide-area SMRs than on

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10/ (...continued)
Commission properly noted in the Refarming proceeding, many of these rules are redundant or unnecessary for most private land mobile licensees including, at that time, SMRs. To retain these rules now that SMRs will become CMRS providers would be impractical and unnecessary in light of earlier Commission determinations.

cellular carriers. Under the Commission's proposed revisions to Part 22, cellular carriers would be required to file applications only when they are making major modifications to the borders of their CGSAs. Since cellular providers employ their spectrum exclusively within their respective CGSAs, there is no need, the Commission has reasoned, to require applications for internal system changes.[11/] Wide-area SMRs will not have this luxury because they do not license exclusive blocks of spectrum in their service territories. In modifying their "cell sites," wide-area SMRs continually need to coordinate around pre-existing co-channel systems. Each and every modification therefore would require the payment of a $230 application fee, resulting in much larger fees being paid by the nascent wide-area SMRs.

18. The site-by-site licensing requirement also warrants protecting modification applications from the filing of mutually exclusive applications. As the Further Notice recognizes, given the extensive licensing of 800 MHz SMR spectrum, changes to wide-area systems will involve the trading and consolidation of spectrum. Allowing the filing

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11/ Revision of Part 22 of the Commission's Rules Governing the Public Mobile Services, CC Docket No. 92-115, Notice of Proposed Rule Making, 7 FCC Rcd. 3658, 3694-95 (1992).

of mutually exclusive applications in these situations invites frivolous filings. For purposes of distinguishing between "major" and "minor" modifications in the wide-area SMR context, Southern supports the Commission's proposal to treat "internal" changes (i.e., within footprint changes) as minor and immune from mutually exclusive applications. See Further Notice at 60.

19. Wide-area SMRs need to develop competitive systems, and this need warrants liberal pre-grant construction and operational rules. Licensees should be able to commence construction at any time, at their own risk, provided they comply with environmental and aviation hazard rules. Southern also supports the Further Notice's proposals to extend the wide-area SMR license term and to grant them renewal expectancies. See Further Notice at 61-62.

20. Finally, Southern supports all CMRS licensees' ability to assign stations after construction. The Further Notice suggests that there be a one-year holding requirement for licenses granted in "unserved areas." Further Notice at 62-64. Defining unserved areas for wide-area SMRs would be a cumbersome process because the concept is foreign to the station-by-station roll-out of SMR systems. Since the

Commission is considering auctioning off unserved cellular areas in the future, Southern suggests there no longer is any need for a holding requirement.

C. Spectrum Aggregation Cap

21. The Commission should establish limitations on the aggregation of spectrum that are based upon promoting competitive conditions, particularly by maximizing efficient entry by digital wide-area SMRs. To these ends, Southern submits that the Commission should augment its other limitations on spectrum aggregation (e.g., in the cellular and PCS arenas) by limiting wide-area SMRs' accumulation of frequencies which exceed the number needed for realizing scale economies. As shown below, in the metropolitan areas where the Commission has noted an aggregation of frequencies, only about one half of the available 800 MHz SMR spectrum is needed to achieve most of the benefits of scale economies.

22. Both Commission precedent and economic evidence support Southern's position. In analyzing the analog cellular environment over a decade ago, the Commission perceived that the declining cost curve that initially resulted from adding frequencies to a system based upon frequency re-use was not continuous and that "most of the

economies could be realized at allocations significantly less than. . .40 MHz."[12/] Today, digital technology enables vastly more efficient use of spectrum.[13/] As noted in the November 18, 1993, Petition for Reconsideration of Nextel Communications, Inc., pending in GEN Docket No. 90-314, at 3, 6, and 10, digital voice modulation provides for six voice calls per channel bandwidth.[14/] The flattening of the cost curve, which indicates that most of the benefits of scale economies have been achieved, occurs much earlier in the digital environment than in the analog environment of a decade ago. In a typical large metropolitan area, the digital cellular cost curve flattens out between 70 and 140 frequencies. As a result, the economies of operation in such a city are not significantly augmented by operations utilizing in excess of 140 frequencies. Accordingly, a wide-area SMR frequency aggregation limit of 140 frequencies in Metropolitan Statistical Areas would achieve a balance-point to maximize efficient entry consistent with the

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12/ An Inquiry Into The Use Of The Bands 825-845 MHz and 870-890 Mhz For Cellular Communications Systems, 86 F.C.C.2d 469, 474 (1981) (emphasis added).

13/ Calhoun, Wireless Access and the Local Telephone Market 581 (1992) (cumulative effects of digital technology and software increase by a factor of fifteen over analog the traffic that can be carried in the same bandwidth).

14/ See also Huber, Geodesic Network II, 1993 Report on Competition in the Telephone Industry, 4.128.

principles enunciated by the Commission in establishing the cellular telephone spectrum structure.[15/]

23. In support of its proposal, Southern also relies upon an expert economic evaluation of the scale economies associated with incremental additions of frequencies in the context of wide-area SMRs. Southern includes this analysis, Assessing Network Economics of SMR Services (the "Assessment"), as an attachment to its Comments and incorporates it herein by reference. As shown by the biographical appendix to the Assessment, experts at the consulting firm of Booz Allen & Hamilton developed and applied the economic model described in the report. The analysis demonstrates that the engineering economics cost curve, reflecting incremental unit costs declining as frequencies are added, becomes negligible between 70 and 140 frequencies (the "Competitive Range"). By requiring wide-area SMRs to operate without exceeding the Competitive Range, the Commission can maximize entry by diverse service providers.

15/ In implementing a 140-frequency cap, Southern recommends that the Commission count the number of frequencies an 800 MHz SMR uses to provide service within the relevant area. A frequency would be "used to provide service" in an area if any part of the frequency's FCC-

> The overall character of the network capital scale curve is such that a 'knee' in this curve exists between 70 and 140 frequencies. In particular, the network capital economics of operation at 140 frequencies are not significantly incrementally disadvantaged versus operation at 210 or 240 frequencies.

Assessment at 1.

24. Two telling statistics show the negligible impact of frequency additions in excess of the Competitive Range. First, increasing frequencies from the Competitive Range to the 210-280 range results in only a very small reduction (2-3%) in operating costs. Assessment at 8. Also, a discounted cash flow analysis (which eliminates the effects of frequency hoarding, related speculation, and anticompetitive effects from valuation) shows that increasing frequencies from the Competitive Range to the 210-280 level results in no meaningful increase in the expected valuation of the firm. Assessment at 9.

25. Reliance on a gross 40 MHz limit, as proposed in the Further Notice, for all CMRS services risks anticompetitive effects regardless of the geographic area (BTA or MTA) used by the Commission. The Commission's proposal assumes incorrectly that all CMRS services occupy the same market. As the Commission's discussion indicates, ordinary dispatch-oriented SMR service clearly is not a

product substitute for cellular telephone. PCS will not even appear in the market for several years, and persuasive evidence of product substitution is not available.[16/] Although industry press has identified the potential for wide-area SMRs to compete with cellular telephone, as shown in the Nextel Petition for Reconsideration, supra at 3 and 6, wide-area SMRs will offer two-way voice, data, and dispatch jointly. Thus, wide-area SMRs can readily meet the combined wide-area service needs of utilities, government agencies, other companies with operations on public rights of way, and other industries, in addition to the conventional local fleet dispatch provided by traditional SMRs.

26. The Commission would be ill-advised to leap to an assumption that all wireless systems occupy the same market and to rely on a huge spectrum limitation to preserve competitive conditions. Reliance on a single large spectrum cap that vastly exceeds that which is necessary to exploit scale economies in a frequency re-use environment would

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16/ Calhoun, Wireless Access, supra, at 563, 573, and 578. See also Nextel Communications, Inc. Petition for Reconsideration, supra at 15 ("The Commission's conclusion. . . draws an unwarranted and over broad conclusion from the cellular experience without recognizing that PCS is a different service with different, and as yet, unexplored potential and prospects").

invite the strategic acquisition of frequencies to retard competitive entry, particularly in medium and large cities that could serve as bottlenecks to effective competition in these areas. These bottlenecks would prevent multiple entrants and would delay the broad availability of digital wireless services to communities outside dense urban areas and would preserve premium, supra-competitive, prices in the urban areas.

27. In the context of wide-area SMRs serving large metropolitan areas, the benefits of scale economies can be achieved with significantly lower frequency aggregations than the Commission is now witnessing. The Commission's policies would be poorly served by allowing the accumulation of 800 MHz SMR frequencies in typical cities to exceed the Competitive Range and therefore establish choke points that inhibit efficient entry. The Commission should adhere to the principle of maximizing efficient entry by establishing a cap of one half of the SMR spectrum for wide-area SMRs which serve Metropolitan Statistical Areas.

CONCLUSION

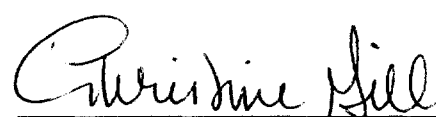
28. Forcing wide-area SMRs to resemble the cellular carriers will, as a practical matter, broaden the regulatory disparity between cellular carriers and wide-area SMRs by

imposing disparate costs of regulatory compliance. Southern urges the Commission to exploit its administrative discretion in order to promote qualitative parity instead. Southern also urges the Commission to adopt a 140-frequency spectrum cap for SMRs.

WHEREFORE, THE PREMISES CONSIDERED, the Southern Company respectfully requests that the Commission act upon its Further Notice of Proposed Rule Making in a manner consistent with the views expressed herein.

Respectfully submitted,

THE SOUTHERN COMPANY



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ASSESSING NETWORK ECONOMICS OF SMR SERVICES

Atlanta, GA
January 14, 1994

BOOZ·ALLEN & HAMILTON INC.

Study Objectives and Summary Result

This report summarizes Booz•Allen's interim conclusions regarding the following three questions:

(1) Does competitiveness of Digital SMR operators with existing cellular operators depend on network economies of scale that can only be achieved by the use of virtually all available radio channels (280) in a large metro market such as Atlanta?

(2) Do the network scale economics of frequency utilization significantly disadvantage operation at 80 or 140 frequencies versus operation at 210 or 280

(3) In general, what are the network economics of scale associated with incremental frequencies?

Summary results developed to date are as follows:

The competitiveness of a MIRS operator offering cellular-like services in the Atlanta market will not be materially affected by the number of radio channels it controls, provided a minimum is exceeded.

The overall character of the network capital scale curve is such that a "knee" in this curve exists between 70 and 140 frequencies. In particular, the network capital economics of operation at 140 frequencies are not significantly incrementally disadvantaged versus operation at 210 or 280 frequencies. The difference in cumulative capital per subscriber is less than $100 given a set of likely assumptions. This correlates to less than a 10% impact on overall cost structure and discounted cash flow which is well within the range of today's operating variations among cellular businesses.

Introduction

This report examines the network capital economics of a Digital Specialized Mobile Radio (Digital SMR) network in Atlanta, competing in the market for Cellular Telephony. In particular, it answers the question of how competitiveness is affected by the availability of Radio Channels, based on certain assumptions about network parameters in three areas:

(1) Cost and performance of Digital SMR equipment

(2) Network topology

(3) Customer usage

The companies that plan to build Digital SMR networks in Atlanta have each selected Motorola MIRS technology. Accordingly, this analysis is based on MIRS cost and technical characteristics. Little is known publicly about MIRS equipment costs and so the estimates in this paper (which have been derived from comparable cellular equipment costs) are only approximate. The conclusions, however, do not depend strongly on the price of equipment. MIRS technical characteristics are fairly well known–and it is on these that the conclusions rest more heavily.

This report moves from a discussion of MIRS technical principles and network parameters to the analysis of capital scale economies to an assessment of the impact of network capital scale economies on competition.

MIRS Technical Principles and Network Parameters

MIRS (SMR) like AMPS (Cellular) achieves efficient use of radio spectrum by allowing customers at different places to use the same frequency at the same time. The network is engineered so that customers using the same frequencies are always sufficiently separate to prevent interference. This results in a frequency "re-use" pattern. Each cell in the pattern is allocated a unique set of frequencies, which are not re-used in any adjacent cell. So if, N frequencies are available in total, and a 7-cell re-use pattern is designed, each cell can have on average N/7 frequencies. MIRS equipment allows six voice-grade channels to be derived from each radio channel, of which one is used for network control signals. Thus, the average capacity of a cell is

5*N/7 conversations. If 140 frequencies are available, each cell can have 140/7=20. This will provide (6 voice-1 control)*20 radio channels=100 voice channels at each cell.

The number of customers supported by this configuration depends on how much each customer uses the mobile service (usage level), and on the effectiveness with which empty channels can be matched with customers needing to communicate (utilization).

Usage level is conventionally measured in the "busy hour" i.e., the period in which aggregate network usage is highest. Cellular operators today experience peak usage of between 0.5 and 1 BHCCS per customer (Busy Hour Call Hundred Seconds) i.e., on average each customer makes calls of 50-100 seconds in the busy hour.

Utilization efficiency depends on a trade-off with the grade of service: utilization cannot in practice approach 100%, because if it did, any customer who tried to make a call, would be almost certain to find the network full. The likelihood that a user will find the network busy, and thus be unable to place a call, is known as the blocking rate, measured as the ratio of unsuccessful to successful calls in the busy hour.

Figure 1: Theoretical Network Capacity

$$n_{vc} = ErlangB_{0.01}\left[\frac{(P-1)F}{N_{ru}}\right]$$

$$N_{vc} = E \times n_{vc} \times N_{cell}$$

$$N_{sub} = \frac{N_{vc}}{U_{sub}} \times 3600$$

P = Ratio of Voice channels to Radio Channels in the MIRS system
F = Total radio frequencies available
N_{ru} = Number of cells in the re - use pattern
n_{vc} = Theoretical Number of voice channels available per cell
E = Overall network efficiency (actual utilization / theoretical utilization)
N_{cell} = Number of Cells in the Network
U_{sub} = Usage per sub (BHCCS)
N_{sub} = Number of subscribers supported

Cellular networks are typically designed to block no more than 1% of calls in the busy hour. The utilization that will ensure blocking of a given level is given by a standard engineering model: known as the Erlang B formula. It assumes a certain

probability distribution of call arrivals, a mean rate of call arrival and a mean talk time. In practice, to achieve 1% blocking, utilization will be 60-80%. This is still a theoretical value, because it assumes that customer usage distribution is known sufficiently far in advance to deploy just the right amount of network capacity in right place. In practice, this is impossible, because customer usage varies by time of day (not all busy hours coincide), and plant cannot efficiently be continuously re-deployed. So the theoretical "Erlang B" capacity of the network must be further degraded by an efficiency factor. In total, then, the number of customers that a given network can support is given in Figure 1.

Thus, the important network parameters are the maximum number of cells, the number of available frequencies, the customer usage, the re-use number and the network efficiency.

Note that, if the number of cells can be increased, there is no limit to the capacity of the network even at a fixed number of frequencies. There is however, a practical limit to the number of cells, because adding cells means making others smaller to preserve the re-use pattern. There is a minimum practical cell size, which dictates the technical maximum capacity of the network.

Increasing the number of available frequencies in theory allows the same subscriber base to be served with fewer cells, since each cell can have proportionally more frequencies.

As average customer usage decreases (as it has continually since the launch of cellular services), the number of subs that can be supported by a given network capacity increases. Increasing the number of cells in the re-use pattern decreases the number of subs that can be supported because a given pool of frequencies must be shared by more cells; so the capacity formula would be adjusted to $5*N/N_{ru}$, where $N_{ru}>7$. Increasing network utilization efficiency increases the number of subs that can be supported.

Network Economic Scale Analysis

Availability of Radio Spectrum could affect competitiveness in two ways. 1) By constraining the maximum number of subscribers to a level below that which the business would otherwise attain. 2) By causing the deployment of more cells than